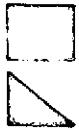


ENVIRONMENTAL RESEARCH & TECHNOLOGY, INC.



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REF: 073-005-144

ERT Doc. P-408-5

24 May 1973

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Attention: Mr. James R. Greaves
ERTS Scientific Monitor, Code 651

Subject: ERTS-A Investigation No. SR126: Evaluate the Application of
ERTS-A Data for Detecting and Mapping Sea Ice

Principal Investigator: James C. Barnes, PR525

Gentlemen:

This is the fourth bimonthly Type I Progress Report describing work performed by Environmental Research & Technology, Inc. (ERT), for the National Aeronautics and Space Administration under Contract No. NAS 5-21802. This report covers the period from 28 February to 10 May 1973.

The purpose of this investigation is to evaluate the application of imagery from the ERTS-A RBV and MSS sensors for surveillance of sea ice. The objectives are: to determine the spectral interval most suitable for ice survey; to measure the scale and types of ice features that can be detected; and to develop simplified interpretive techniques for differentiating ice from cloud and for mapping ice features. The results will enable the maximum use of data from ERTS and future spacecraft systems for operational ship routing, compilation of ice charts, and scientific research.

A. ACCOMPLISHMENTS DURING REPORTING PERIOD

1. ERTS Data Sample

During this reporting period, the remainder of the color composite data request submitted last November was received. In addition to receiving the remaining scenes, seven scenes that were duplicates of data sent earlier were also received.

Late in the reporting period, the initial sample of ERTS coverage of the Arctic following the winter dark period was received. The sample consists of 12 passes during the period between 25 March and 11 April 1973. The dates and areas covered are shown in Table 1.

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E73-10595) EVALUATE THE APPLICATION OF
ERTS-A DATA FOR DETECTING AND MAPPING
SEA ICE Bimonthly Progress Report, 28
Feb. - 10 (Environmental Research and
Technology, Inc.) 9 p HC \$3.00 CSCI 08L

In reviewing the ERTS data catalog, we noticed that on 27 and 28 February and 6 and 7 March imagery was collected over the Bering Sea. These dates were during the period of the Bearing Sea Experiment (BESEX), which took place primarily in the area to the south of St. Lawrence Island. In this experiment, extensive data including aerial photography of the sea ice were collected by the NASA CV-990 aircraft. ERT personnel participated in the experiment, so are familiar with the various types of data. We, therefore, have submitted a request for the ERTS data over the Bering Sea for use in this investigation. Although this imagery is not from one of our standing order areas, the availability of the aerial photography and narrative description by the onboard ice observer presents a unique opportunity to study the ERTS imagery with concurrent ground truth. The 6 and 7 March ERTS imagery is of particular interest since these passes crossed the precise BESEX area.

2. Correlative Ice Data

No new aerial survey ice charts were acquired during this reporting period. Steps have been initiated to acquire whatever correlative data are available for the BESEX area on the dates of the ERTS coverage. It is anticipated that aerial photographs, descriptions of ice types by the ice observer on board the aircraft, and ice observations from the supporting ice breaker will be available.

3. Results of Data Analysis

Correlation Between ERTS-1 Imagery and Aerial Ice Observations

Ice features mapped from ERTS imagery have been compared with the features indicated on aerial ice observation charts for eight instances. In six of these the ice charts were from the Canadian Ice Forecasting Central and in the other two from the Navy Ice Forecast Office. The ERTS coverage and aerial survey were either one or two days apart in all instances except one, when they were on the same day. It is possible, therefore, that changes in the ice conditions could have taken place during the intervening periods. The results of the comparative analyses are summarized in the following paragraphs.

- Hudson Bay, ERTS imagery for 27 July - ice chart for 29 July. This comparison is discussed in an earlier progress report. In general, very good agreement is observed in the location of the ice edge extending southwest of Coats Island and in the location of an ice belt south of Southampton Island. The ice chart indicates that the majority of the floes are smaller than the "medium floe" category (100-500 m across), which also is in good agreement with the ERTS imagery. Surface features (ridges, hummocks, and puddles) that are reported to exist on the "small floes" (20-100 m across) cannot be detected in the ERTS data.

• Beaufort Sea, ERTS imagery for 2 August - ice chart for 29 July. The location of the pack ice boundary and the ice concentrations in various areas mapped from the imagery agrees well with the ice chart. Although reported hummocks and puddles are difficult to detect in the ERTS data, ridges can be detected.

• Beaufort Sea, ERTS imagery for 8 August - ice chart for 7 August. This region was mostly cloud covered on 7 August, so only a small area was charted. Within the charted section, two areas that are reported as 9/10 and 6/10 first year ice respectively, appear to be consolidated pack ice in the ERTS data. Reported ridges can be seen in the ERTS data, but the reported puddles cannot be detected.

• Byam Martin Island and Viscount Melville Sound, ERTS imagery for 22 August - ice chart for 21 August. A radar ice edge reported north of Byam Martin Island is charted about 20-30 miles northwest of the ice edge mapped from the ERTS imagery. However, an open water area along the east coast of Melville Island reported on the chart is in very good agreement with open water mapped from ERTS. In this area, differences in ice age and some reported surface features cannot be detected in the imagery.

• Crozier Channel and M'Clure Strait, ERTS imagery for 4 September, ice chart for 3 September. Ice concentrations are in good agreement, but reported surface features are difficult to distinguish in the ERTS data.

• Beaufort Sea near Alaskan Coast, ERTS imagery for 7 October, ice chart for 7 October. In this instance, close agreement is observed between the pack ice edge indicated on the chart and mapped from ERTS. Moreover, new ice indicated to be forming along the coast can be detected in the ERTS imagery. The young ice that is detectable appears to consist of gray-white and gray ice; the new ice and nilas ice that are charted cannot be detected in the imagery.

• East Coast of Greenland, ERTS imagery for 7 October, ice chart (radar ice edge only) for 6 October. The location of the radar ice edge averages about 20 n mi east of the location of the ice edge mapped from ERTS. However, the ERTS imagery on this date is very dark, and a rather diffuse ice edge appears near the eastern limit of the ERTS coverage; therefore, additional ice patches or ice strips may very well exist farther to the east.

• East Coast of Greenland, ERTS imagery for 10 October, ice chart for 11 October (radar ice edge only). As in above case, the radar ice edge is located well to the east of the apparent ice edge in the ERTS imagery.

In summary, the comparative analysis made to date have shown generally good agreement between the locations of ice edges and ice concentrations as indicated on aerial ice observation charts and as mapped from ERTS imagery. The agreement with two radar ice edges in the Greenland Sea, however, is not as close as is the agreement with most of the ice edges indicated to have

been mapped visually. Ice surface features indicated to be ridges and thaw holes are readily detected in the ERTS imagery; hummocks, puddles, frozen puddles, and rafted ice are not as readily detected in the imagery, although brightness variations can be distinguished on some ice surfaces, thereby suggesting their presence. In the ERTS imagery, younger forms of ice (gray-white and gray ice) can usually be distinguished from older ice; the older ice contains brightness variations suggesting the presence of ridges, thaw holes, puddles and hummocks, whereas the younger ice appears much more uniform in reflectance. Areas indicated on ice charts to consist of the darker new or nilas ice appear to be essentially ice-free in the imagery. Also, in areas indicated to consist of mixtures of multi-year, second year, or first year ice, differences in reflectance in the ERTS imagery that could be associated with each ice type are not readily apparent.

Initial Data Sample Following Winter Dark Period

Late in the reporting period, a preliminary examination was made of the ERTS imagery collected during the early spring season. During this season most of the land areas appear to be surrounded by fast ice; moreover, because of the snow cover it is often difficult to distinguish the land itself from the fast ice. In areas such as the Greenland Sea, where much open water was observed in the late summer and fall, compact pack ice (10/10 concentration with no water visible) now exists.

Despite the extensive ice cover, however, many features of interest can be detected. For instance, the compact pack ice can be readily distinguished from the coastal fast ice because of the variations in reflectance within the ice field in contrast with the uniform reflectance of the fast ice. Also, in some instances, such as in the western part of Baffin Bay, a lead separates the pack ice from the fast ice. Even in the mid-Beaufort Sea, numerous leads appear. Of particular interest is that distinct differences in reflectance exist within the leads. It is believed that these differences are the result of the lead opening and then partially refreezing; the refrozen ice is not snow covered and thus has a significantly lower albedo than the older snow-covered ice. Furthermore, preliminary measurements of the edges of some large leads show conclusively that in addition to lateral movement, significant shearing movements have also taken place. In these instances, one boundary of the lead, when mapped onto a transparent overlay, can be slid and fit exactly with the other boundary.

A separate discussion of significant results and their relationship to practical applications or operational problems, including estimates of the cost benefits of any significant results, is attached to this progress report.

B. PLANS FOR NEXT REPORTING PERIOD

During the next reporting period, it is anticipated that the ERTS imagery for the Bering Sea and the correlative ice data collected through the BESEX experiment will be acquired. Upon receipt of these data, the analysis will be undertaken, with particular attention given to the development of keys to identify ice types in the ERTS imagery. Because of the availability of the excellent correlative ice observations, we believe that the analysis of the Bering Sea data will be extremely valuable for evaluating the application of ERTS imagery for mapping sea ice.

Detailed analysis of the ERTS data from this spring season will also be undertaken. Where necessary, the imagery will be reprocessed using the 70 mm negatives, and the ice features will be mapped and ice types identified. Contact will be made with the Navy and Canadian Ice Forecasting Offices to acquire whatever aerial ice observation charts are available. In areas where data were available last summer the differences in the ice distributions will be mapped; similarly, differences in the appearance of ice features during the season of minimum snow cover (last summer and fall) and during the season of maximum snow cover (spring) will be examined; and if repetitive coverage is available the ice break-up process as summer approaches will be investigated.

C. PUBLICATIONS

During this reporting period, a paper resulting from the effort performed under the contract was submitted for publication in Arctic Bulletin, a new journal of the National Science Foundation, Office of Polar Programs. Notification of the acceptance of the paper has been received.

D. LISTING OF STANDING ORDER CHANGE AND DATA REQUEST FORMS

Retrospective Data Request Forms for the ERTS scenes covering the Bering Sea area on four dates (27 and 28 February, and 6 and 7 March) were submitted to the ERTS User Service Office on 9 May. A Standing Order Addition Form defining the area was also submitted on the same date.

E. PROBLEMS

No problems to impede the progress of the investigation are anticipated.

Table 1 ERTS-1 Data Sample Providing Coverage of Arctic
Following Winter Dark Period

	<u>Date (1973)</u>	<u>Identifier Number</u>	<u>Geographic Area</u>
1.	25 March	1245-13412 through-13430	Greenland - East Coast
2.	25 March	1245-15300 through-15302	Southern Baffin Island and Hudson Strait
3.	26 March	1246-15361 through-15354	Southern Baffin Island and Hudson Strait
4.	26 March	1246-17160	Northern Baffin Island
5.	28 March	1248-15451 through-15471	Davis Strait to Northern Hudson Strait
6.	28 March	1248-19123	Northwest Territories (No Ice Visible)
7.	29 March	1249-19175 and-19181	Amundsen Gulf
8.	1 April	1252-19341 through-19352	Prince of Wales Strait, Amundsen Gulf
9.	1 April	1252-21150 through-21184	Beaufort Sea
10.	2 April	1253-14335	Labrador Sea
11.	3 April	1254-14394	Labrador Sea
12.	11 April	1262-20295 through-20325	Beaufort Sea, Prince Patrick Island

ERTS IMAGE DESCRIPTOR FORM
(See Instructions on Back)

P-407

DATE 24 May 1973

PRINCIPAL INVESTIGATOR Mr. James C. Barnes

User ID P525
GSFC

NDPF USE ONLY

D _____
N _____
ID _____

ORGANIZATION Environmental Research and Technology, Inc.

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Ice Flows	Snow	Coast	
1245-13412 MP	X			Ice Pack, Leads, Fractures, Cumulus
1245-13423 MP	X	X	X	Islands, Fast Ice, Ice Pack, Bays, Fiords, Icebergs
1245-13430 MP		X	X	Fiords, Mountains, Glaciers, Islands, Fast Ice
1252-21155 MP		X		Ice Pack, Leads, Fractures,
1252-21161 MP	X	X		Ice Pack, Leads, Fractures
1252-21164 MP	X	X		Ice Pack, Leads, Fractures, Stratocumulus
1252-21175 MP	X	X	X	Ice Pack, Leads, Fractures, Stratocumulus
1252-21182 MP		X		Rivers, Valleys, Mountains, Tundra

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO ERTS USER SERVICES
CODE 563
BLDG 23 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406

REF: 073-005-144
NASA, Greenbelt, Md.

-6-

ERT Doc. P-408-5
24 May 1973

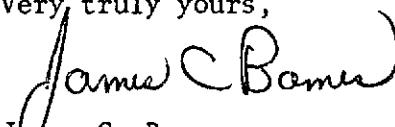
F. ERTS IMAGE DESCRIPTION FORMS

Image Descriptor Forms are attached to this progress report.

G. FUNDS

It is anticipated that the remaining funds will be adequate for successful completion of the investigation.

Very truly yours,



James C. Barnes
Principal Investigator

JCB/bcs

DISCIPLINE: MARINE RESOURCES AND OCEAN SURVEYS, SEA ICE MONITORING

TITLE: EVALUATE THE APPLICATION OF ERTS-A DATA FOR DETECTING
AND MAPPING SEA ICE (SR NO. 126)

PRINCIPAL James C. Barnes (PR525)
INVESTIGATOR: Environmental Research & Technology, Inc.
429 Marrett Road, Lexington, Massachusetts 02173

DISCUSSION OF SIGNIFICANT RESULTS:

Generally good agreement has been observed between the location of ice edges and ice concentrations as indicated on aerial observation charts and as mapped from ERTS imagery. Moreover, ice surface features reported to be ridges and thaw holes are readily detected in the ERTS imagery. Reported hummocks, puddles, frozen puddles, and rafted ice are not as readily detected in the imagery, although brightness variations on some ice surfaces can be distinguished, thereby suggesting their presence. In the ERTS imagery, although dark new ice and nilas are difficult to detect, other younger forms of ice (gray-white and gray ice) can be mapped and can usually be distinguished from older ice because of their lower, more uniform reflectance.

A preliminary examination of the initial sample of ERTS imagery collected this spring, during the season of maximum ice extent, indicates several ice features of interest. Compact pack ice can be distinguished from coastal fast ice, and many leads can be mapped, even in the mid-Beaufort Sea. Several leads have distinct variations in reflectance, which are believed to result from the lead opening and then partially refreezing. Measurements of some leads also show that in addition to lateral movement, significant shearing of the ice has apparently taken place.